Assessing the Potential for Retrofitting Diesel Power Systems

September 28, 2004

Per Lundsager
Tom Lambert
Ian Baring-Gould

Session Overview

- Provide a quick overview of the issues relating to the installation and/or retrofitting of remote power systems
- Review a of design checklist
- Introduction to NREL software, specifically HOMER

Session Goals

Obtain a quick understanding of how do you get started in looking at renewables.

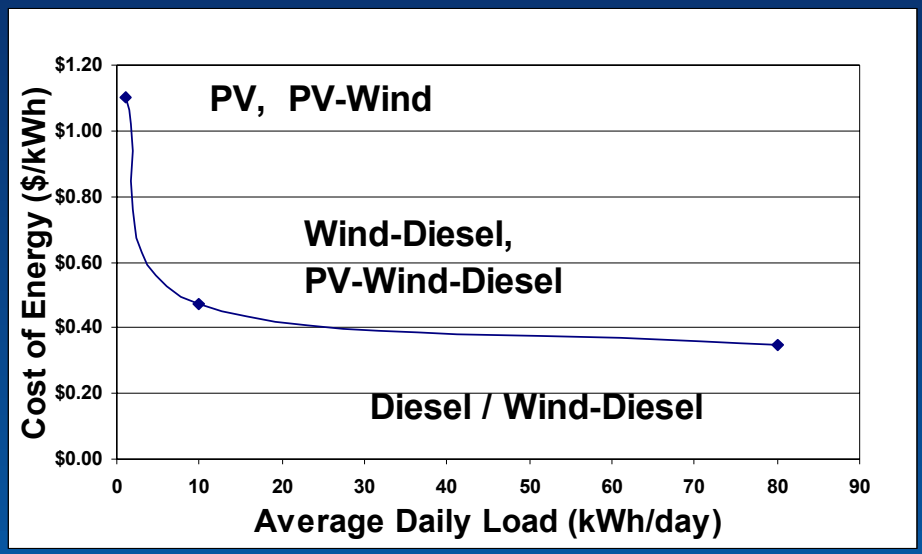
Needs for Hybrid Power Design

- **Community loads:** What are the loads to be assessed
- **Available renewable resources:** What resources are available close to the site.
- **Spatial layout of the community:** How dispersed is the population.
- **Cost of the alternative energy options:** Cost of the different options to supply power.
- **Residents' ability and willingness to pay:** What can the residents pay and are they willing to do so.
- **Non-Institutional considerations:** Other considerations for the communities in question

Community Loads

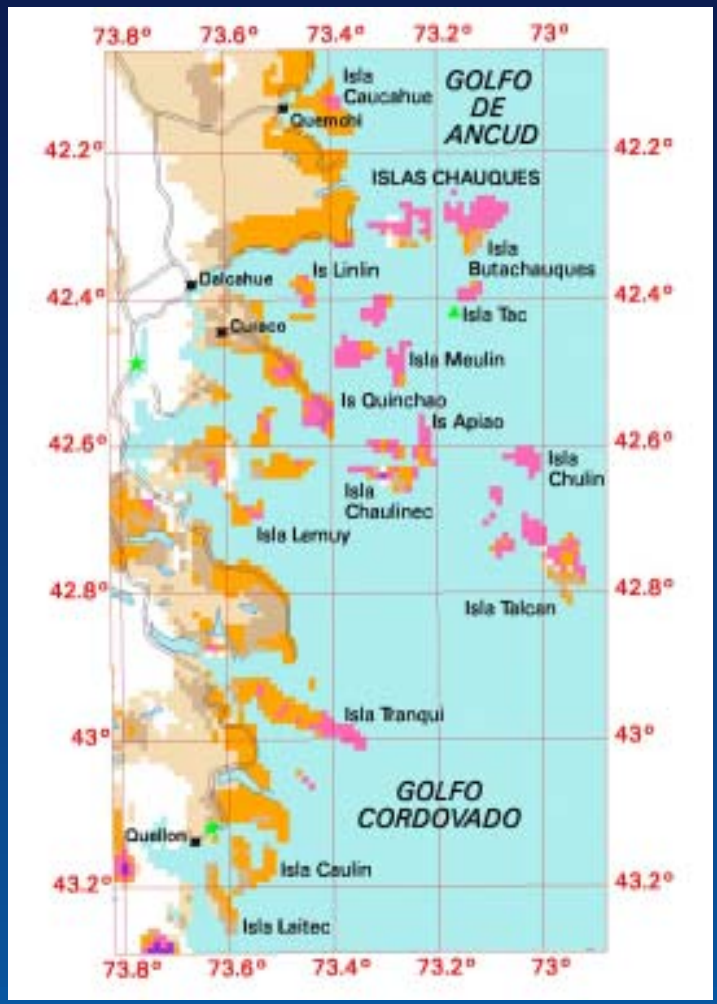
Community load will greatly impact the system design

- Load estimation
- Projected growth, or reduction, of loads/population
- Quality of the electric service, the number of hours per day
- Large inductive loads must be considered.



COE can change drastically with the expected load, note how the system design also changes.

Available Renewable Resources



What resources are available?

- Resources near the community
- The daily and seasonal variations of resources
- Macro and microscopic assessment required
- Some models/methods available to predict resource

Wind resource map for Chiloe Islands

Spatial Layout of the Community

Directly impacts the economics of meeting the power requirements for the community

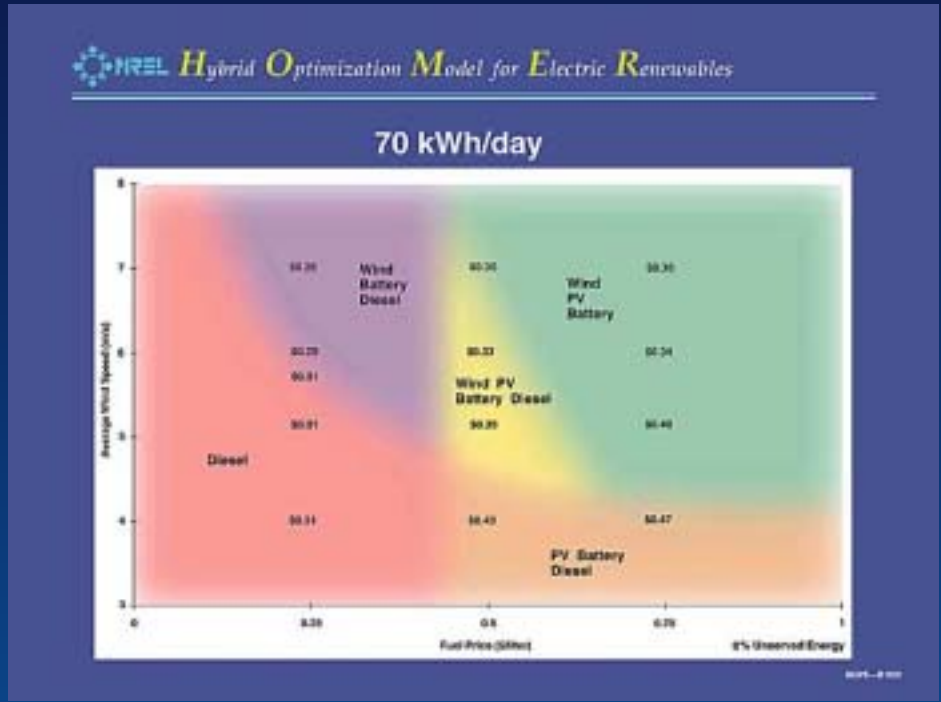
- Individual home, cluster or centralised power systems
- Acceptance of different qualities of service
- Allows political decision on connections

Mixture of individual and centralized power systems used for this island community. How much more would it cost to connect everybody?

Cost of Alternatives

For a true least cost solution the cost of the all feasible methods need to be assessed

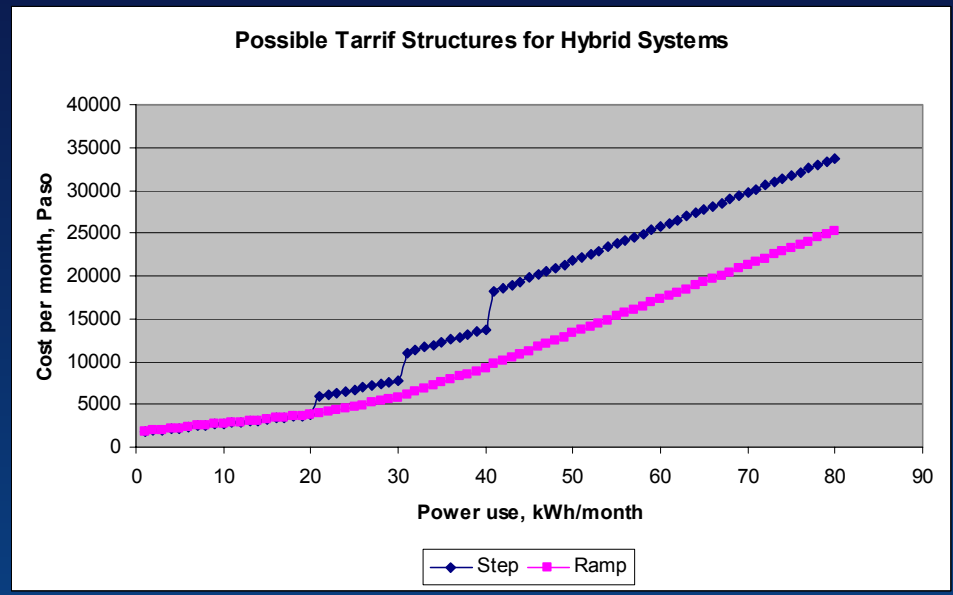
- True cost of diesel fuel to the community
- Distance to existing high voltage transmission line
- Equipment cost, both renewable and conventional
- Cost based method of analysis



Willingness/Ability to Pay

An understanding of the community economics is important

- Impact of subsidized power
- Cost determines the type of service to be provided
- "New" tariff structures
  - metering of houses
  - multiple rate structure
  - Pre-payment



Multi-part tariff structure requires people who use more power to pay more for the service. Targets large power users not the poor - large consumers pay for expansion

Social Considerations

Any social considerations that might impact the use or choice of the technology

- Level of education to supply maintenance
- Nomadic populations that will move around or spend a lot of time in other areas.
- Special needs or beliefs

Steps in the design process

- Need specification: Why or what is needed
- Macro resource assessment
- Pre-feasibility study
- Initial impact study: Willingness to pay, technical impact of system modification
- Detailed data collection including renewables
- System modeling and economic evaluation
- Final system design, infrastructure specification
- System installation
- Maintenance specification and action items

Needs Specification

- Why is energy needed at this specific site
- What type of energy is needed
  - Direct use for water pumping, water purification or ice making
  - Small power requirements for a school or health post
  - Electrifying a small community
  - Expanding the hours of operation of a large diesel plant
- What are the requirements for this energy
  - On demand power production
  - Intermittent power
  - Large loads, small loads
  - High or moderate reliability

General Resource Assessment

What resources are available?

Conduct Macro-Resource Assessment

- Identify the basis for the project interest
- Obtain initial data on the existing plant
  - Equipment cost data
  - Economic parameters
  - Operation expenses, fuel and labor
- Obtain basic resource data
  - Renewable availability
  - Diesel fuel cost (including transportation)
- Identify limiting criteria
- Specify the criteria that will be used to made decisions on the analytical results

Pre-feasibility Studies...

What is the most economical way to supply the power needed to provide the needs of the community/system

- Answer the basic questions that are of interest
  - basic power system design, estimate of installation and O&M expense, base line cost of alternatives, yearly power production, and fuel consumption
- Studies can be done by the host organization or contracted out to other private companies. - Be Careful either way as it requires skill to know the results of a study prepared externally is accurate.

Initial Impact Assessment

Once the costs and basic system have been determined, will the project work financially as well as technically?

Questions like

How will the project be financed?

What does this do to the cost of energy?

Will it increase or decrease the or quality of service?

Is there a developed infrastructure to support the changes?

Who will be responsible for system O & M?

Are there social issues that need to be addressed?

Detailed Data Collection

If there is support for the project then more detailed analysis needs to be conducted based on the results of the pre-feasibility study

- **Site selection and identification:** Where should the new plant elements be installed, difficulties with this
- **Detailed resource assessment:** Detailed data collection of the selected resources at the site. Obtain time series data for the resources
- **Load and plant data:** Obtain specific data from the diesel plant to be retrofitted. Load, plant configuration, operating strategy

Economic figures of merit - COE

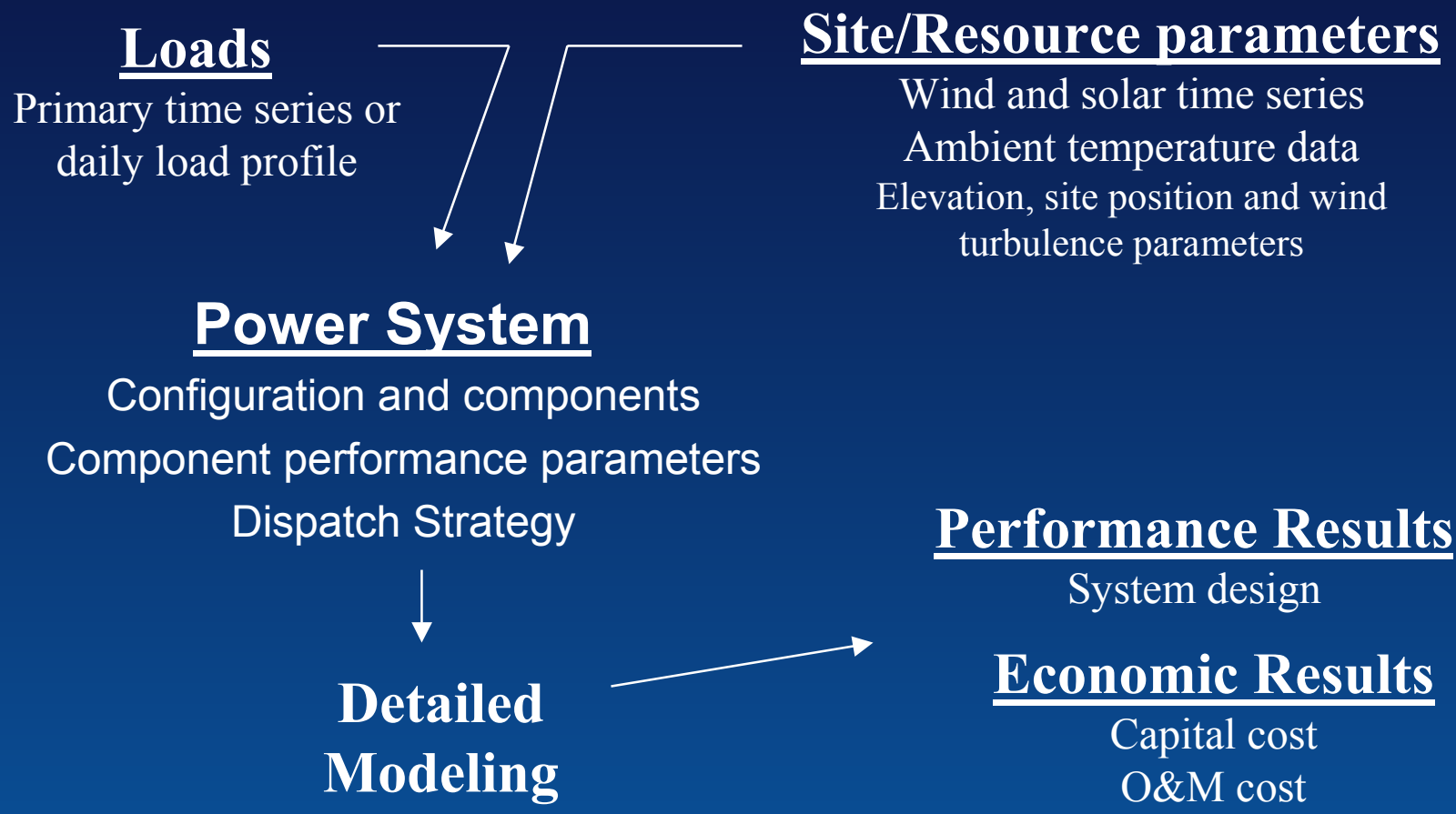
Cost of Energy - COE ($/kWh production)

How much does it cost to produce a kWh of energy from the power system.

Method:

- Calculate the costs for the system for each year of the project, discount those back to the start of the project (Total discounted cost of the system)
- Estimate the yearly energy production of the plant for each year of operation and discount this back to the start of the project (Total discounted energy production from the system
- Divide the first number by the last

Analysis Procedures



Systems Analysis

- HOMER software used to look at different electrification options for the island
- Hybrid2 used to refine the analysis, consider specific equipment choices and determine the expected cost of the power system

Final System Design and Instalation

Determine final system requirements

Contract for design and installation

- Construct grid/in house wiring
- Insure delivery of equipment
- System commissioning
- Obtain manuals and engineering drawings

In-house construction

- Produce engineering drawings
- Varity dynamic operation
- Order equipment
- BOS specification
- Construct grid/in house wiring
- Design and install foundations
- Instalation of system
- Commissioning

Operating System

Important considerations

The design of hybrid power systems is not a trivial task that can be taken lightly.

Hybrid power systems are complex, from a technical and control standpoint, the designer must understand this.

- Designers must have a good understanding of
  - The technology of hybrid systems
  - Standard power system design
  - Economics
  - Social and mechanical infrastructure

They should employ modern tools to assist in the design process

Conclusions

- The experience needed will depend on the situation, though some understanding is critical
- Many considerations need to be addressed in the design of hybrid power systems
  - Financial
  - Technical
  - Social
- NREL has simulation models that can be used to make this process easier
- An understanding of power system economics is critical to the design of power systems